National Aeronautics and Space Administration

Contact information:
addisonh@gmail.com
504-392-7443

Autonomous Monitoring and Control of Rocket Test Systems

Addison Howenstine - Duke University

Introduction

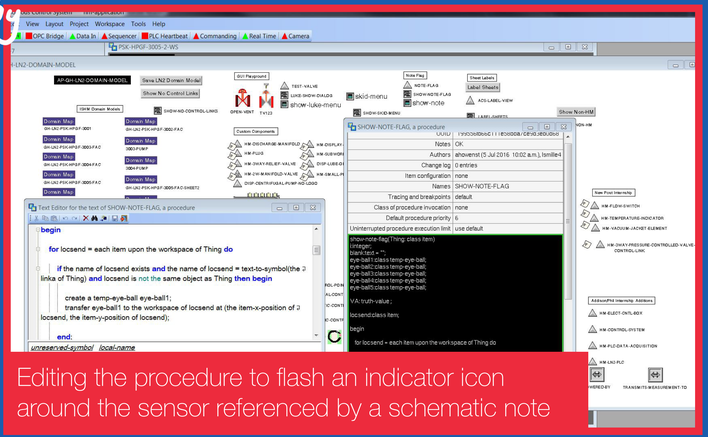
I'm going into my third year majoring in Electrical & Computer Engineering and Computer Science at Duke University hoping to use my technical skills in a future career in aerospace to help contribute to the next giant leap for mankind.

This summer we are working with G2, an expert systems software platform to develop an autonomous monitoring and control system for the High Pressure Gas Facility (**HPGF**) at Stennis Space Center (**SSC**) as well as for the launch systems at Kennedy Space Center (**KSC**).

Typical G2 workflow showing object oriented modularity allowing the programmer to make object and instance modifications that effect the program in real time

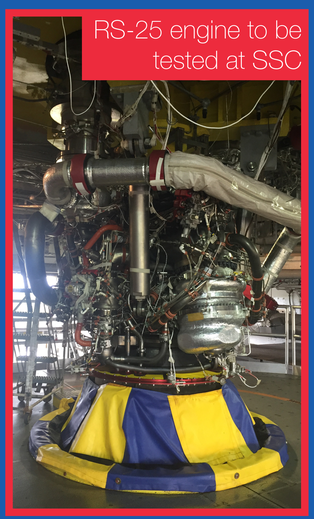
Objectives

- Use the NASA-developed Autonomous Operations Mission Development Suite (**AO-MDS**) as a platform for intelligent Integrated System Health Management (**ISHM**) of the Nitrogen System to monitor sensor networks at the HPGF and make decisions based on sensor readings and anomaly detection,
- Model "Domain-Maps" to reflect each sheet of the Liquid Nitrogen System (**LN2**) schematics with system defined class definitions, icons, and functionality for each object represented in the schematic,
- Improve functionality of Domain-Maps to connect sheets with animated connection posts and schematic notes with flashing pointers to reference points within the sheet,
- Develop a "SymCure" map in G2 for model-based diagnosis of system and sensor errors using virtual sensor indicators and G2 events to identify problems and determine potential root causes and solutions,
- Debug the G2 system currently running at the HPGF for easier use in preparation for G2 to eventually replace the monitoring platforms currently in place allowing for greater control and expert system decision making.



Editing the procedure to flash an indicator icon around the sensor referenced by a schematic note

Skid pumps in the LN2 system at the HPGF

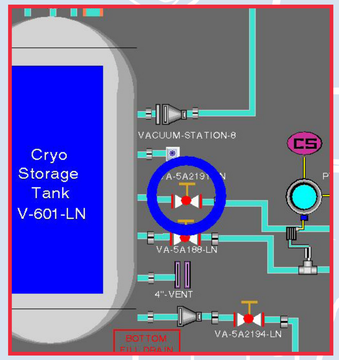


RS-25 engine to be tested at SSC

G2 table for a temperature sensor

B test stand at SSC

Implementation



In G2, each object in a system (e.g. sensor, valve, pump, etc.) can be modelled abstractly and instantiated specifically. It can then be connected or related to other objects in the module. This allows the system to generate logical animations and to search along a path within a system as well as make better decisions about possible causes of errors.

Sensors can contain real time readings, health status, and a searchable name and key.

A **connection-post** by name will link to the related connection-post on a different sheet of the schematic.

Valves such as an **hm-globe-valve** can be opened and closed by logic within G2.

A **note-flag** in a schematic will link to the relevant object within the Domain-Map and blink.

Summary

The use of the G2 expert systems software platform for autonomous monitoring and control at NASA has great potential for ISHM of various aerospace systems. It has already been integrated at both SSC and KSC and has the capacity to make aerospace systems at other NASA facilities more autonomous and secure.

This internship at SSC working with Dr. Fernando Figueroa has opened my mind to the possibilities of using modern technology to make space exploration safer and cheaper. I have enjoyed the opportunity to work in an exciting environment, coding in a new language, and learning a great deal about expert systems related to aerospace.

Under the excellent mentorship of Dr. Fernando Figueroa, special thanks to Esteban Duran, Mark Walker, & Mark Turowski.

Publication # : EP-2016-07-00036-SSC